AD-A052 255 SCRIPPS INSTITUTION OF OCEANOGRAPHY LA JOLLA CALIF F/G 4/2
APPLICATION OF THE METHOD FOR TRACKING STORMS BY FORERUNNERS OF--ETC(U)
MAR 48 N6ORI-111

UNCLASSIFIED SIO-WAVE-77 NL

| OF |

AD
A052255

END
DATE
FILMED
5-78
DDC

SCRIPPS INSTITUTION OF OCEANOGRAPHY
UNIVERSITY OF CALIFORNIA

APPLICATION OF THE METHOD FOR TRACKING STORMS BY FORERUNNERS OF SWELL

HYDROGRAPHIC OFFICE
OFFICE OF NAVAL RESEARCH
CONTRACT N6ori-111

SIO-Wave Report No. 77
March 1948
10 p.
11 Mar 48

Scripps Institution of Oceanography
of the University of California
Task VI, Contract N6ori-111

APPLICATION OF THE METHOD FOR TRACKING STORMS BY FORERUNNERS OF SWELL

1. Introduction. The purpose of this study was to test the method of tracking storms by use of forerunners of swell as described by Munk (1947). Copies of analyzed weather maps for the North Atlantic from 1 November 1945 through 30 November 1946 were made available by the Navy Weather Central, Washington, D. C. Wave spectrograms from Pendeen, England were provided by the Oceanographic Research Group, Admiralty Research Laboratory, Teddington, England. These records show amplitude factor versus period, as obtained by harmonic analysis of the original wave records. Analyses were made for twenty minute intervals every two hours.

2. Procedure. The records were inspected in order to find bands of forerunners that could be identified for a period of six hours or more. The identifying features of the band, such as the fore edge and the rear edge, were carefully marked. Next, the time of arrival, as shown on the analyzed wave records, and the period of these identifying features were tabulated and plotted on a "Storm Tracking Graph" following the instructions given by Munk (1947). This determined the foci which gave a time and position for the storm that generated the swell. Then, and then only, were the weather maps consulted to determine if a storm actually existed at the given time and place.

Twenty storms in all were studied, ten by Major A. R. Gordon, Jr., Air Corps, and ten by the author. Care was taken to select the fetch in a

consistent manner. In general, only winds which blew in a direction within 30 degrees of the isobars were included.

3. Accuracy of Method. Of these twenty cases, fourteen gave good results, i. e., the error was less than 10% of the measured distance at the computed time, and less than 400 miles in actual distance (see Table 1). Of the six remaining cases, four gave fair results, i. e., storms could be approximately located, but computed distances did not conform with measured distances. In some cases points that should have been at the far side of the fetch were actually on the near side. For the two remaining cases, storms which corresponded to the forerunners could not be located. The computed time was taken as correct and the whole error attributed to the distance of the storm from Pendeen.

The twenty cases gave 106 foci, the errors of which were distributed as follows:

TABLE 1

Percentage error	Number of foci for which observed distance minus computed distance were in error by stated percentage of observed distance	
	(+)	(-)
0 - 15	20 1/2	29 1/2
16 - 30	8	19
31 - 50	7	8
51 +	1	5
Error in nautical miles	**Number of foci for which observed distance minus computed distance were in error by stated number of nautical miles**	
0 - 250	24 1/2	35 1/2
251 - 500	14	15
500 - 750	3	3
over 750	3	8

It is felt that an error of 0 - 15% is within the limits imposed by the interpretations of the wave records, and the analysis of the weather maps, and that different persons would derive results which differ by that amount. It was noticed by Major Gordon and the author that the amount of discrepancy decreased with additional experience. If the work were performed regularly over a period of time the error might be reduced even more.

4. Identification of Features on Spectrogram. Extreme amplitude peaks in the forerunners could usually be identified with the location of the center of the fetch. An arc swung with Pendeen as the center and the computed distance as the radius would almost invariably pass through the center of a fetch associated with abnormally strong winds and would also cross the associated cold front at its strongest point. This suggests that the peaks could be profitably used to locate the most intense part of the storm (which is usually of primary interest). A plot of such intense parts of the storm against time gives a graphic picture of the storm movement as related to its intensity.

In examining a band of forerunners the longest period in the band corresponds to a focus associated with the far side of the storm while short periods of the band in question are associated with the near side of the storm which, in general, is of greatest interest. However, quite often the short periods are obscured by the presence of a second band from another storm which might have been present at an earlier time or a greater distance from the wave recorder. In many cases the long period forerunners of the earlier storm merged with the short period forerunners of the later storm, thus making it impossible to determine the fore edge of the storm in question.

In picking off the fore edge (longest period of band) of the forerunners and plotting its decrease in period, an error is introduced. The theory demands that the period of an identifying feature be plotted, and the focus is then a function of its decrease in period. However, in picking the fore edge of the forerunner band on each observation, the same identifying feature is not used, but a new feature each time, the difference being a function of the storm movement between the times of observation. This can be overcome by identifying a peak near the fore (or rear) edge of the band and plotting its decrease in period. This procedure gives more accurate results than plotting the actual fore edge of the band.

5. Effect of Storm Pattern. The best results were obtained from warm lows. These lows usually originate as waves on a cold front just east of the North American continent, most often near Cape Hatteras. These waves occlude quickly, deepen, and move northeast rather rapidly, finally occupying the region between England and Iceland. These storms are characterized by a strong fetch which moves continuously and is rather regular in its movement.

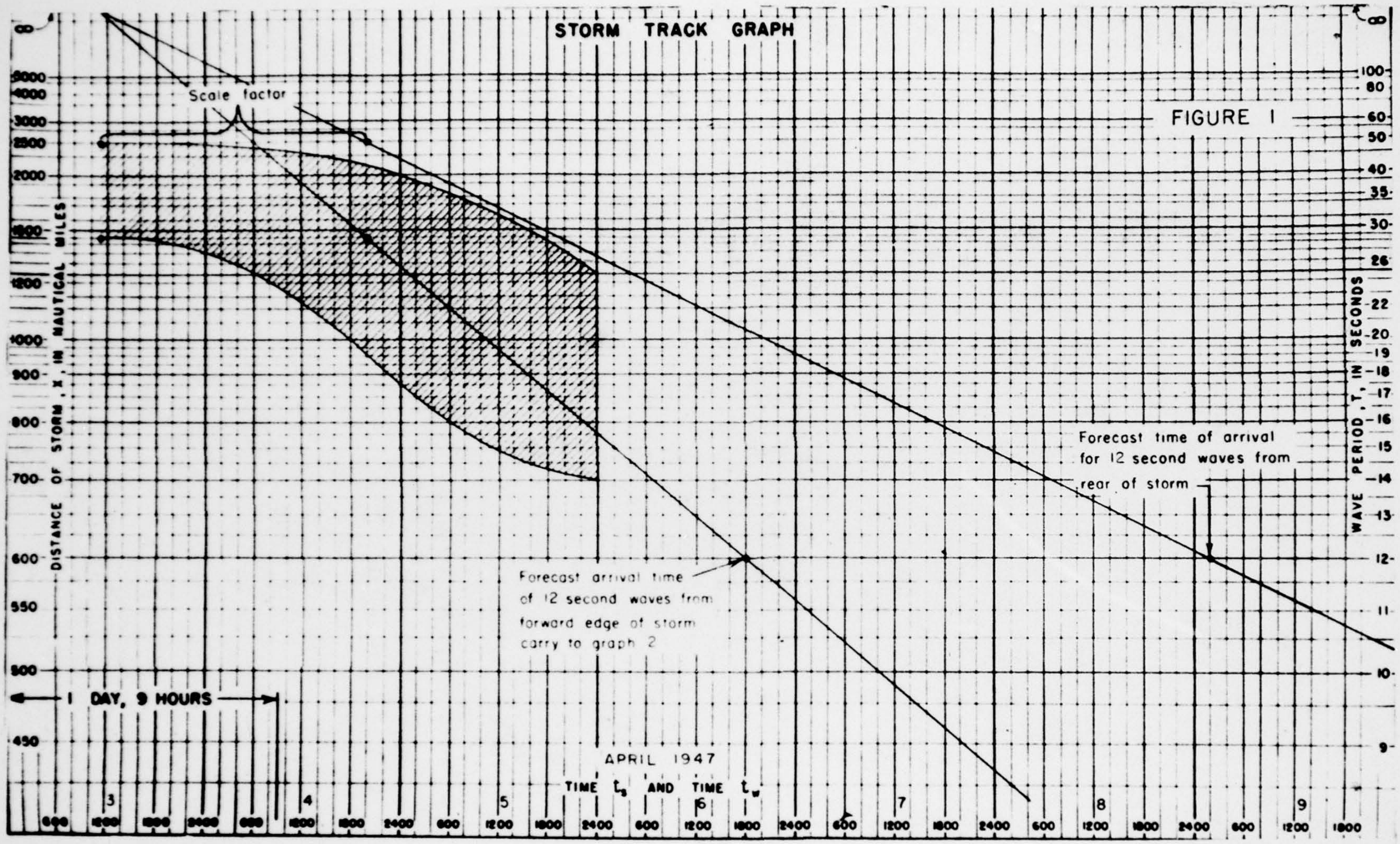
Cold lows, on the other hand, which move into the area near Iceleand, deepen and stagnate, gave poor results. These lows tend to maintain themselves over a period of time and the individual fronts move through the southern edge, with the result that the fetch lengthens and shortens, but does not progress away from its location. Such a situation gave a very jumbled picture on the wave spectrum.

As experience was gained cold lows could be differentiated from warm lows by inspection of the wave spectrum.

6. Rate of Movement. The rate of storm movement was computed for eight storms which were picked at random. The computed speeds were on the average 15% in error. This is considered satisfactory inasmuch as the calculations were subject to the same errors discussed earlier.

7. A Proposed Use of the Method. For a forecaster of sea and swell who is charged with making forecasts for various beach areas, the principles of this paper could be used to determine the time of arrival of high waves from storm centers, provided the forecaster has available accurately analyzed current weather maps of the region in which the storms are generating waves.

If the storm indicates a fetch which will affect the area for which the forecast is being made, then the distance of the fetch to the area is measured. This distance is plotted on the storm tracking graph (Fig. 1) on the day and time it actually occurs. By extending the date line to $x = 00$ and measuring the distance $t_w - t_s$ (which is a scale factor) along the abscissa, two points are obtained. These two points determine a straight line, which, if extended, will give the time of arrival in terms of various periods at the forecast position. From previous experience the forecaster is aware of the periods usually associated with the highest waves. These periods should also be verified by computation from the weather maps according to the methods given in Wind Waves and Swell: Principles in Forecasting (Hydrographic Office, 1944). By keeping a running graph (Fig. 2) of the arrival times, the forecaster can predict by inspection of this graph the arrival time of troublesome waves. The graph will not give the arrival times of local wind waves. For example,


STORM TRACK GRAPH
FIGURE I
Scale factor
DISTANCE OF STORM, X, IN NAUTICAL MILES
WAVE PERIOD, T, IN SECONDS
Forecast time of arrival
for 12 second waves from
rear of storm
Forecast arrival time
of 12 second waves from
forward edge of storm
carry to graph 2
1 DAY, 9 HOURS
APRIL 1947
TIME t_s AND TIME t_w

on 3 April the weather map for 1230 revealed a storm with an associated fetch whose near side was 1400 miles from the wave recorder and whose far side was 2500 miles away. This information is plotted on the Storm Tracking Graph (Fig. 1). Suppose waves of 12 sec period are being considered as associated with the highest waves. According to the graph, 12 second waves from the near side of the fetch will arrive at 1800, 6 April and those from the far side at 0200, 9 April. This information is placed on the running graph (Fig. 2).

Advantages of this method are: (1) that the forecaster will usually have at least two days notice of the arrival of storm waves, allowing him to make an accurate extended forecast; (2) the only required equipment are storm tracking graphs and accurately analyzed current weather maps; (3) the forecast can be made rapidly and many locations can be forecast from one central office.*

ESTIL L. HAMILL
Captain, Air Corps

May 4, 1948
Scripps Institution of Oceanography
of the University of California.

---

*Sverdrup and Munk have recently suggested that the travel time relationship used in the regular sea and swell forecasting method be revised. In the revision, travel time is computed on the basis of the group velocity of the swell at the end of the decay distance. This revision and others are included in Revised Wave Forecasting Graphs and Procedure, Scripps Institution of Oceanography of the University of California, Wave Report No. 73.

The new travel time curves on the regular decay graph give exactly the same travel time values for any given decay distance and wave period as the storm tracking graph. Consequently, the computed arrival of the high swell as determined from weather maps using the regular forecasting procedure will be consistent with the arrival as determined by the method proposed in Section 7 of the present paper. There is, however, a distinct advantage in using the additional evidence furnished by forerunners on wave spectrograms.

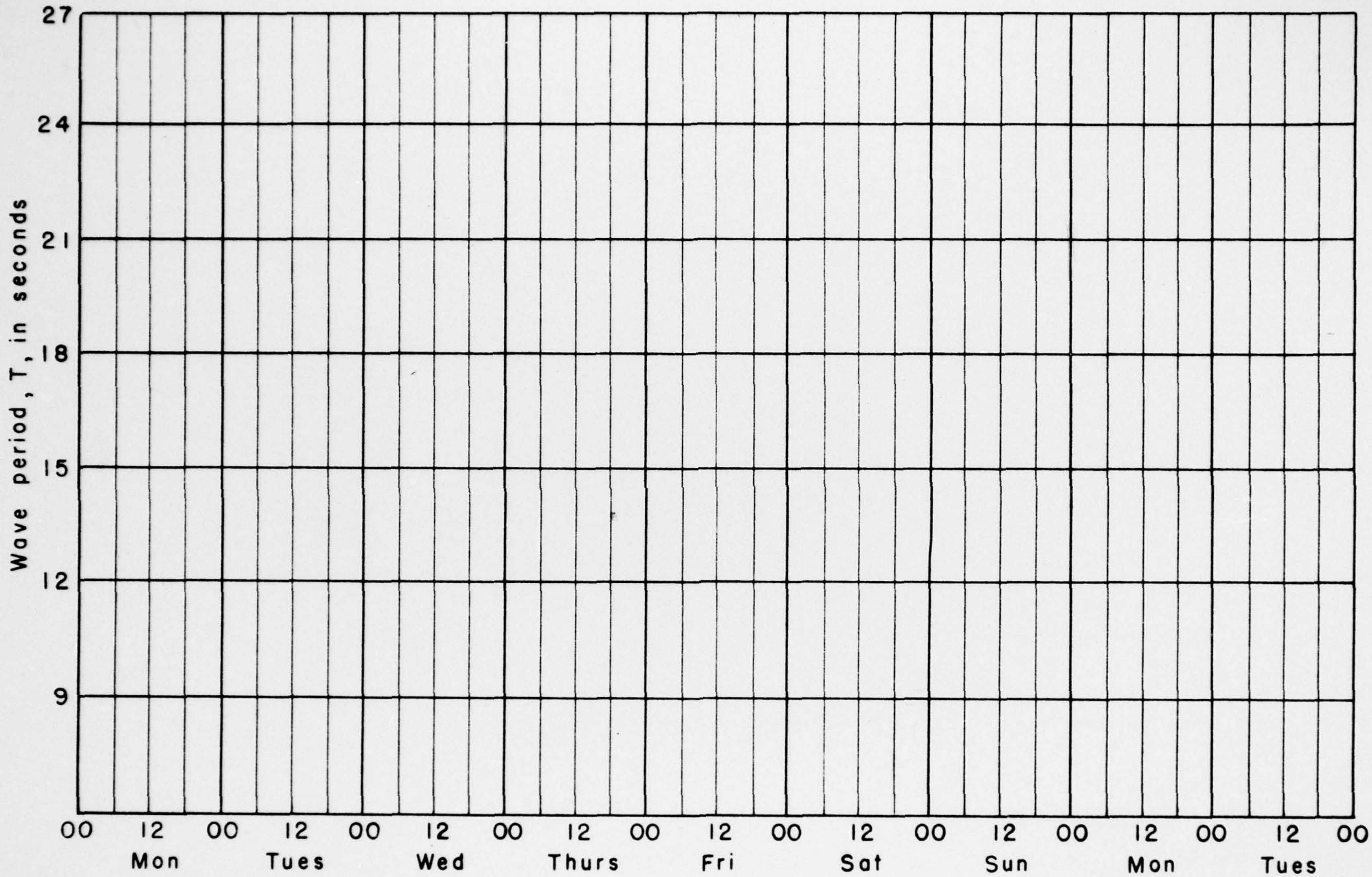

27
24
21
18
15
12
9
Wave period, T, in seconds
00 12 00 12 00 12 00 12 00 12 00 12 00 12 00 12 00 12 00
Mon Tues Wed Thurs Fri Sat Sun Mon Tues

FIGURE 2

REFERENCES

Hydrographic Office, U. S. Navy, Wind Waves and Swell; Principles in Forecasting, H. O. Misc. Pub. 11,275, 61 pp., 8 pls., 1944.

Munk, Walter H., Tracking Storms by Forerunners of Swell, Journal of Meteorology, Vol. 4, No. 2, pp. 45-57, April, 1947.